# Appendix A. Formulas

This appendix contains the formulas you can use during pipeline design and operations.

## A-1. Conversion Formulas.

a. *Pressure (psi) to Head (Feet)/Head to Pressure.*

$$pressure = \frac{(head)(specific\ gravity)}{2.31}$$ **or** $pressure = (0.433)(head)(specific\ gravity)$

**and**

$$head = \frac{(2.31)(pressure)}{specific\ gravity}$$ **or** $$head = \frac{psi}{(0.433)(specific\ gravity)}$$

Conversion constant; 1 psi= 2.31 feet of head of water at 70°F.

b. *Degrees API to Specific Gravity/Specific Gravity to Degrees API.*

$$API\ at\ 60°\ F = \frac{141.5}{specific\ gravity\ at\ 60°\ F} - 131.5$$

**and**

$$specific\ gravity\ at\ 60°\ F = \frac{141.5}{degrees\ API\ at\ 60°\ F + 131.5}$$

**A-2. Bernoulli Equation.** This equation expresses the energy relationship for a liquid flowing through a pipe between two points.

$$\frac{P_1}{W} + Z_1 + \frac{V_1^2}{2g} + H_a = \frac{P_2}{W} + Z_2 + \frac{V_2^2}{2g} + H_f$$

where =

*P = pressure, in pounds per square foot.*
*W = specific weight, in pounds per square foot.*
*Z = elevation, in feet.*
*V = velocity of flow, in feet per second.*
*g = acceleration of gravity, 32.2 square feet per second.*
$H_a$ *= head added by pump between points, in feet.*
$H_f$ *= head loss due to friction between points, in feet.*

**A-3. Darcy-Weisbach Equation.** Use this equation to calculate friction head loss in a pipeline:

$$H_f = \frac{(0.031)\,(f)\,(L)\,(Q^2)}{d^5}$$

where--

*$H_f$ = friction head loss, in feet.*
*$f$ = dimensionless friction factor based on the Reynold's number and the inside roughness of pipe.*
*$L$ = length of the pipe, in feet.*
*$Q$ = flow, in GPM.*
*$d$ = inside diameter of the pipe, in inches.*

**A-4. Reynold's Number.** Use this equation to determine the friction factor required in the Darcy-Weisbach Equation (see Figure C-9, page C-8):

$$\textit{Reynold's number} = \frac{(3{,}160)\,Q}{dK}$$

where--

*$Q$ = flow, in GPM*
*$d$ = inside diameter of pipe, in inches.*
*$K$ = kinematic viscosity, in centistokes (see Figure C-8, page C-7).*